

**EDITORIAL COMMENT**

High-Speed Myocardial Perfusion Imaging: Dawn of a New Era in Nuclear Cardiology?*

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During the past 2 decades, myocardial perfusion imaging (MPI) has become fully embedded in the practice of clinical cardiology. Single-photon emission computed tomography (SPECT) cameras are readily available in both the hospital and the office setting. The stress protocols for MPI, with either exercise or pharmacologic stress, are well established, straightforward, and easily implemented. And there is extensive experience in the published reports and in clinical practice regarding the application of SPECT perfusion imaging for diagnosis, prognosis, and risk stratification. Thus, in an era of technological advances in ultrasound imaging, cardiac magnetic resonance, and cardiac computed tomography, SPECT perfusion imaging is firmly established as an efficient, reliable, and relatively cost-effective procedure in the management of patients with known or suspected coronary artery disease.

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Stress imaging tests have proliferated at an astonishing rate. Stress imaging has increased at an annual rate of over 8% since 1993 in individuals covered by Medicare (1). The majority of these stress imaging procedures represent SPECT imaging. It is estimated that nearly 8 million total SPECT studies (Medicare and non-Medicare) are now performed annually in the U.S., compared with 4 million in 1998 (2). Because diagnostic imaging has increased more rapidly than any other compo-

nent of medical care (3), it is not surprising that all forms of cardiovascular imaging, including SPECT, are now under close scrutiny by the payers of health care. To address these concerns, the American College of Cardiology (ACC) and the American Society of Nuclear Cardiology (ASNC) provided important leadership in developing the first set of appropriateness criteria (4) for cardiovascular imaging. These appropriateness criteria coupled with guidelines that have been in place since 1995, most recently updated in 2003 (5), help to guide the implementation of this technology in clinical practice.

Against this backdrop, is there a role for new imaging technology? Would technological advances that provide images of higher resolution in one-fourth the time have an impact on the annual volume of SPECT studies and its associated costs? What impact would such technology have on our guidelines and performance measures?

It is surprising that SPECT MPI has stood the test of time and flourished, despite the fact that the basic underlying instrumentation has not changed substantially for nearly 45 years. The elemental design remains the gamma camera described by Anger in 1964 (6), which is equipped with a sodium iodide crystal and a series of photomultiplier tubes to enhance count rates. Collimators are required in Anger camera design to provide spatial resolution and hence interpretable images, but the inherent effect of collimation is to reduce count rates. This fundamental limitation in sensitivity requires long imaging times or relatively high doses of radiopharmaceuticals or both. Advances in imaging technology during the past 20 years that are standard and accepted features of the nuclear cardiology laboratory, including the rotating cameras that make SPECT possible, the development of dual-headed and triple-headed SPECT systems, gated SPECT

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to assess ventricular function, and the recent development of attenuation correction software, represent evolutionary changes in the Anger camera, but these embellishments have not altered its fundamental design principles. Thus, the dark side of the Anger camera persists. Current nuclear cardiology practice continues to struggle with the yin and yang of gamma camera performance—that is, the difficult balance between resolution and sensitivity. The result is that excellent image quality requires high radiation doses or prolonged imaging times.

The novel imaging system for cardiac SPECT reported by Sharir et al. (7) in this issue of *JACC Cardiovascular Imaging* represents the first true departure from the Anger camera for clinical SPECT imaging. This unique design uses a series of pixilated solid-state detector columns with cadmium zinc telluride crystals and wide-angle tungsten collimators that, combined with a novel image reconstruction algorithm, provide patient-specific images localized to the heart (region of interest-centric scanning). Compared with the standard gamma camera, this system provides an 8-fold increase in count rates, thereby reducing imaging times significantly, while also achieving a 2-fold increase in spatial resolution. The shorter imaging times of this high-speed system will presumably also result in fewer motion artifacts that will further contribute to improved image clarity. An obvious additional by-product of reduced imaging times will be improved patient comfort.

In the current study, Sharir et al. (7) compared the high-speed SPECT system with a standard Anger camera-based SPECT system in a series of patients undergoing a technetium-99m sestamibi rest/stress protocol. Imaging times of 16 min and 12 min for stress and rest acquisitions, respectively, for conventional SPECT were reduced to 4 and 2 min, respectively, for high-speed SPECT. Despite imaging times that were decreased 4-fold for stress acquisitions and 6-fold for rest acquisitions, high-speed SPECT provided images that were comparable or better in resolution than those achieved with conventional SPECT; the overall diagnostic interpretation with qualitative and semi-quantitative analyses was the same.

The report of Sharir et al. (7) represents a very important step forward. The investigators have clearly used out-of-the-box thinking in design of the high-speed SPECT system and demonstrated that high-speed, high-performance SPECT MPI is now possible in patients. These are exciting findings based on revolutionary changes in instrumentation.

But will high-speed SPECT revolutionize the field of nuclear cardiology and usher in a new era of MPI? This is quite possible, but more work beyond these initial observations is needed to realize this potential, as pointed out by the authors.

The study of Sharir et al. (7) was small, involving only 44 patients who fulfilled specific selection criteria. Larger studies involving multiple laboratories and a broader range of patients will be necessary to confirm these initial findings, and it seems that the authors are already planning this next step. Rather than merely comparing the results of high-speed SPECT with those of conventional SPECT, definitive trials comparing imaging results with coronary angiography will be necessary to establish the true diagnostic accuracy, especially if high-speed SPECT indeed is shown to provide higher-quality images. It is conceivable, on the basis of Bayesian principles, that higher image quality that detects smaller perfusion defects might also result in a greater number of false positive findings, thereby reducing the specificity of high-speed compared with conventional SPECT.

Finally, because this represents an entirely new technology, economic considerations must also be considered when and if this technology evolves toward clinical implementation in the marketplace. Depending on the expense of high-speed SPECT, the financial burden of replacing cameras and computer systems might be warranted in a large, busy laboratory in which increased throughput of patients would represent a major advantage of high-speed SPECT. However, there might also be difficulties in a larger laboratory with multiple existing cameras in integrating the new imaging systems and computers into the ongoing operations of the existing imaging network of standard SPECT cameras. Smaller laboratories with lower patient volume might or might not find the advantage of increased patient throughput to be important enough to justify the expense.

The promise of high-speed MPI is more than merely reduced imaging time and more rapid patient throughput. One could also image slightly longer with lower doses of radiopharmaceuticals, thereby reducing radiation doses to patients as well as costs to the laboratory, while still obtaining images of higher resolution than those achieved with Anger camera-based SPECT systems. The overall impact on the cost of imaging will ultimately determine the usefulness and practicality of high-speed SPECT. One assumes that reduced imaging times coupled with reduced radiopharmaceutical

doses should be cost effective. Such considerations could have a potential impact on future appropriateness of SPECT imaging.

High-speed imaging systems could also promote the development of new short-lived radiotracers or even resurrect an agent such as technetium-99m tetroborate (8), whose short physical half-life proved too rapid for standard gamma cameras to image appropriately. Such agents would further reduce the total time for the complete rest/stress study.

The advent of high-speed MPI, as represented by high-speed SPECT, does signify a revolutionary

advance in instrumentation and image reconstruction, with unique characteristics that improve both resolution and sensitivity compared with conventional SPECT cameras. Whether it will revolutionize the field of MPI, and in a cost-effective manner, can only be decided by time, effort, and experience. However, it certainly has the potential to do so.

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